# Models of the Universe

Hubble Ultra-deep field

Graham School Master of Liberal Arts Program

Rocky Kolb

Spring 2006

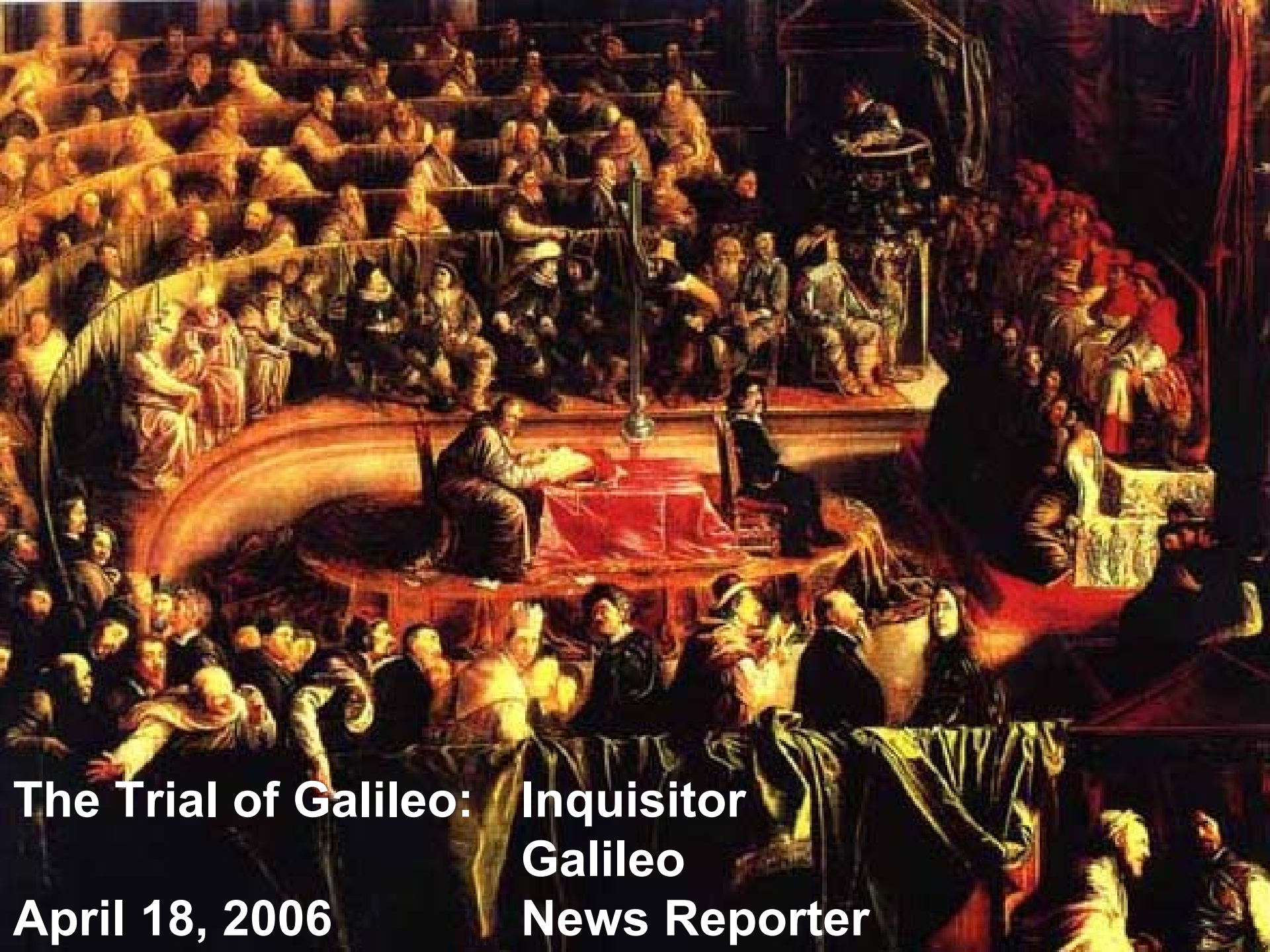
Rocky Kolb
Productions
Presents

*The Dialogue C*
*Two Chi*

, 2006

UNRATED!!!!!!
contains cosmologically explicit material

Need three thespians


The Trial of Galileo:
Inquisitor
Galileo
April 18, 2006
News Reporter

**Models**

**Theories**

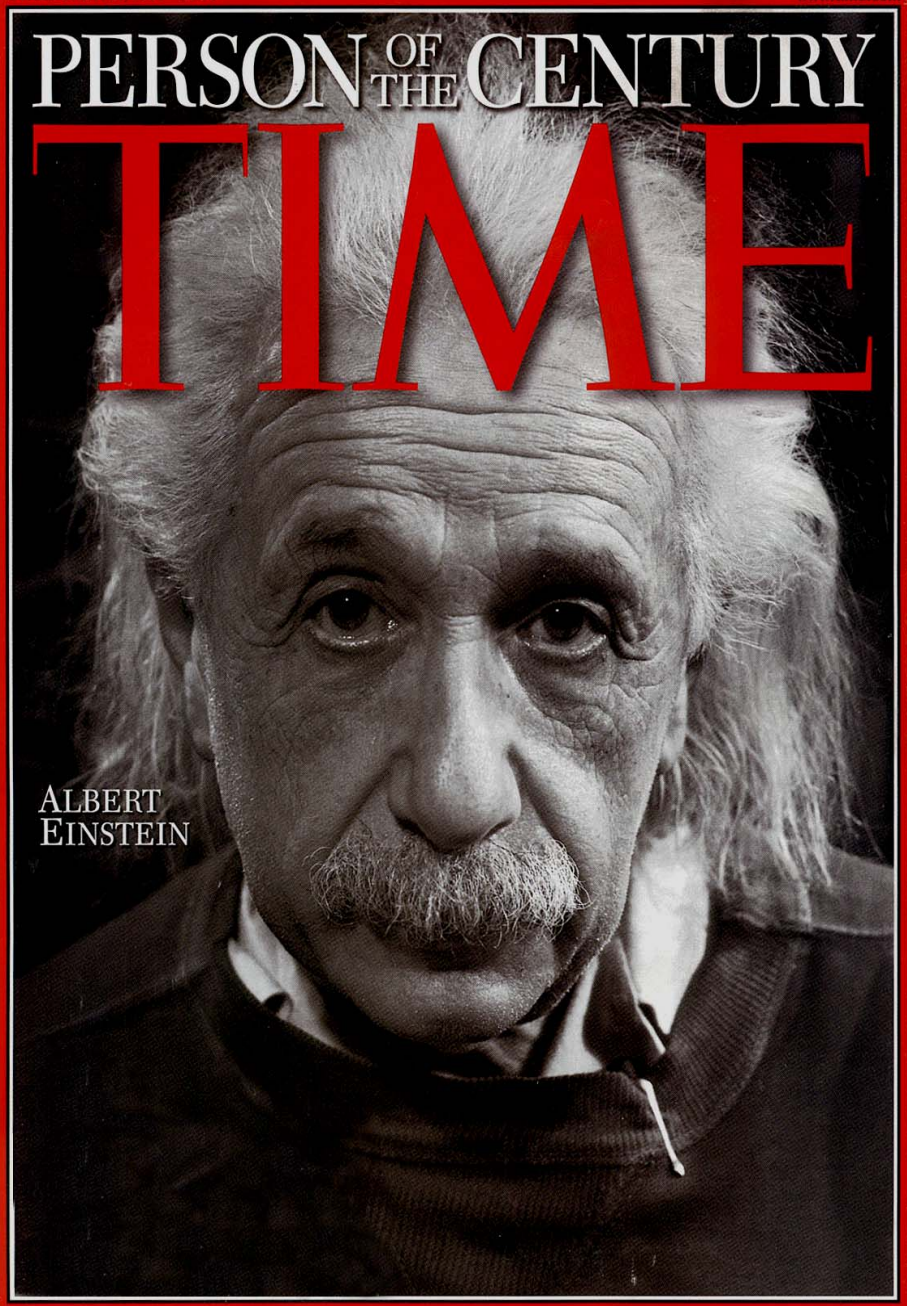
**Laws**

DECEMBER 31, 1999 $4.95

www.time.com

# PERSON OF THE CENTURY

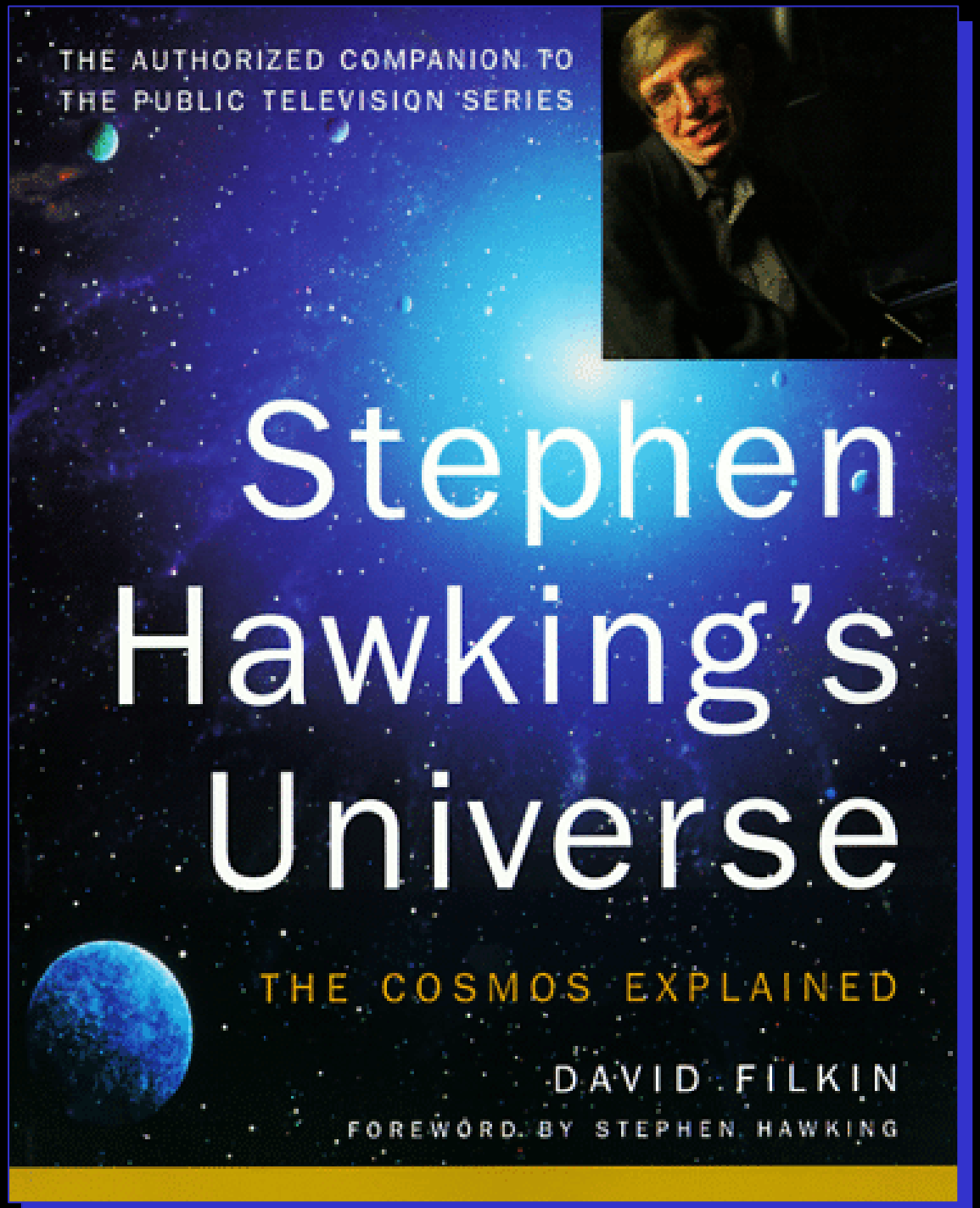
# TIME



ALBERT
EINSTEIN

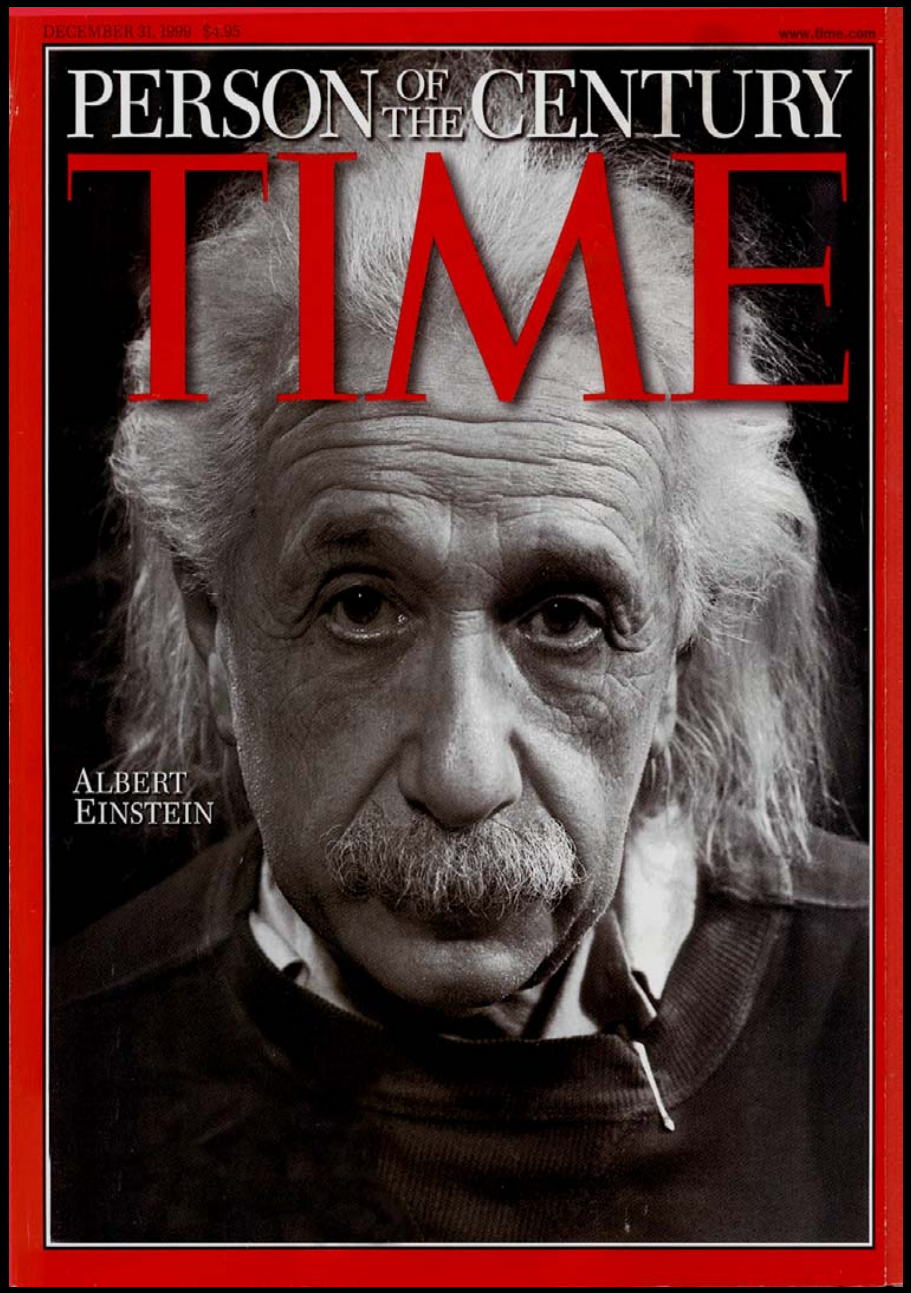
“The most beautiful thing we can experience is the mysterious. It is the source of all true art and all science. Those to whom this emotion is a stranger, who can no longer pause to wonder and stand rapt in awe, are as good as dead: their eyes are closed.”

Albert Einstein




It's your universe too!

**Edwin Hubble**
**1929**




Einstein, ca. 1952

Einstein, ca. 1912

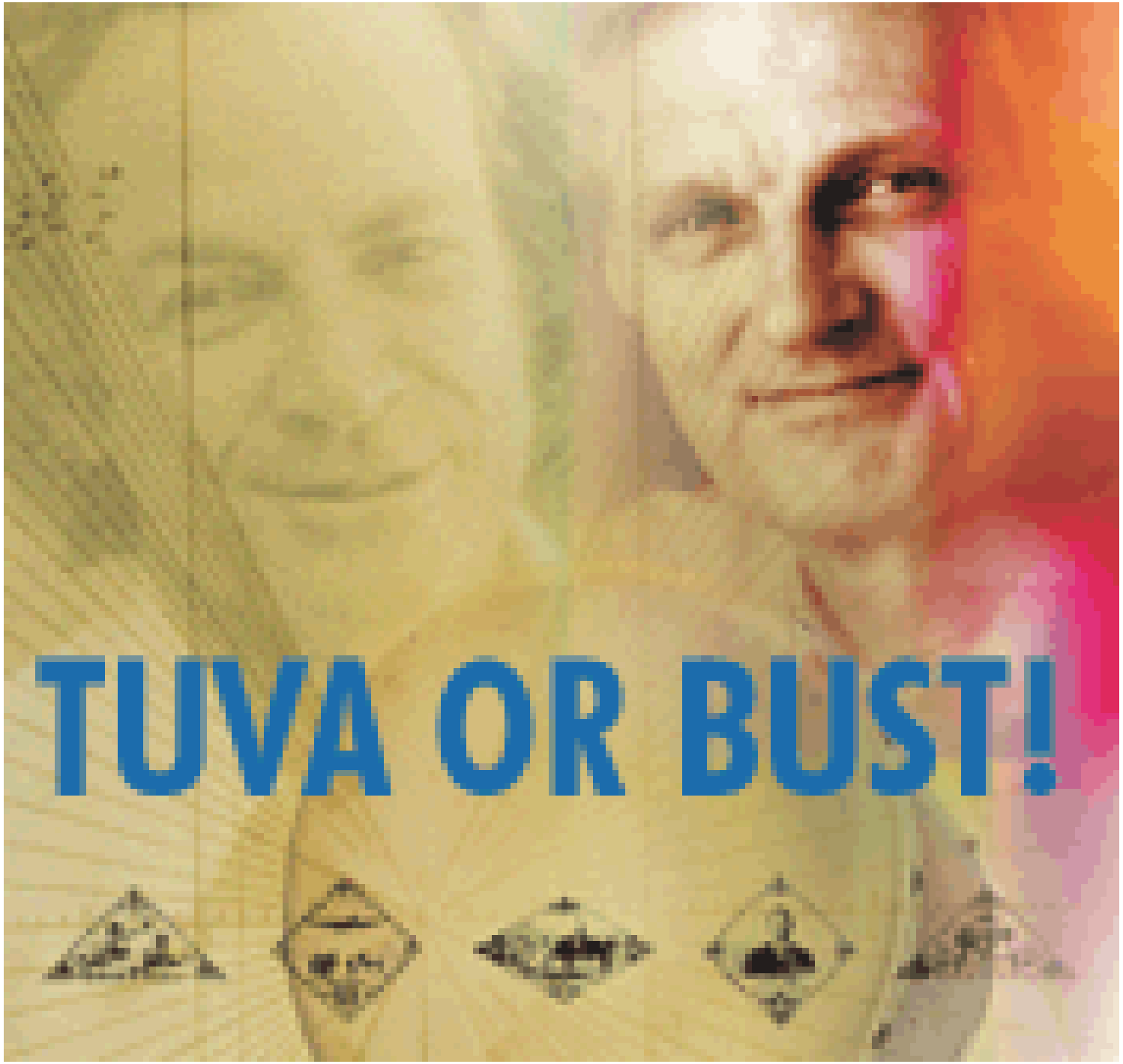
“Once you are able to accept that space is curved and time is relative … wearing stripes with plaids seems relatively normal."

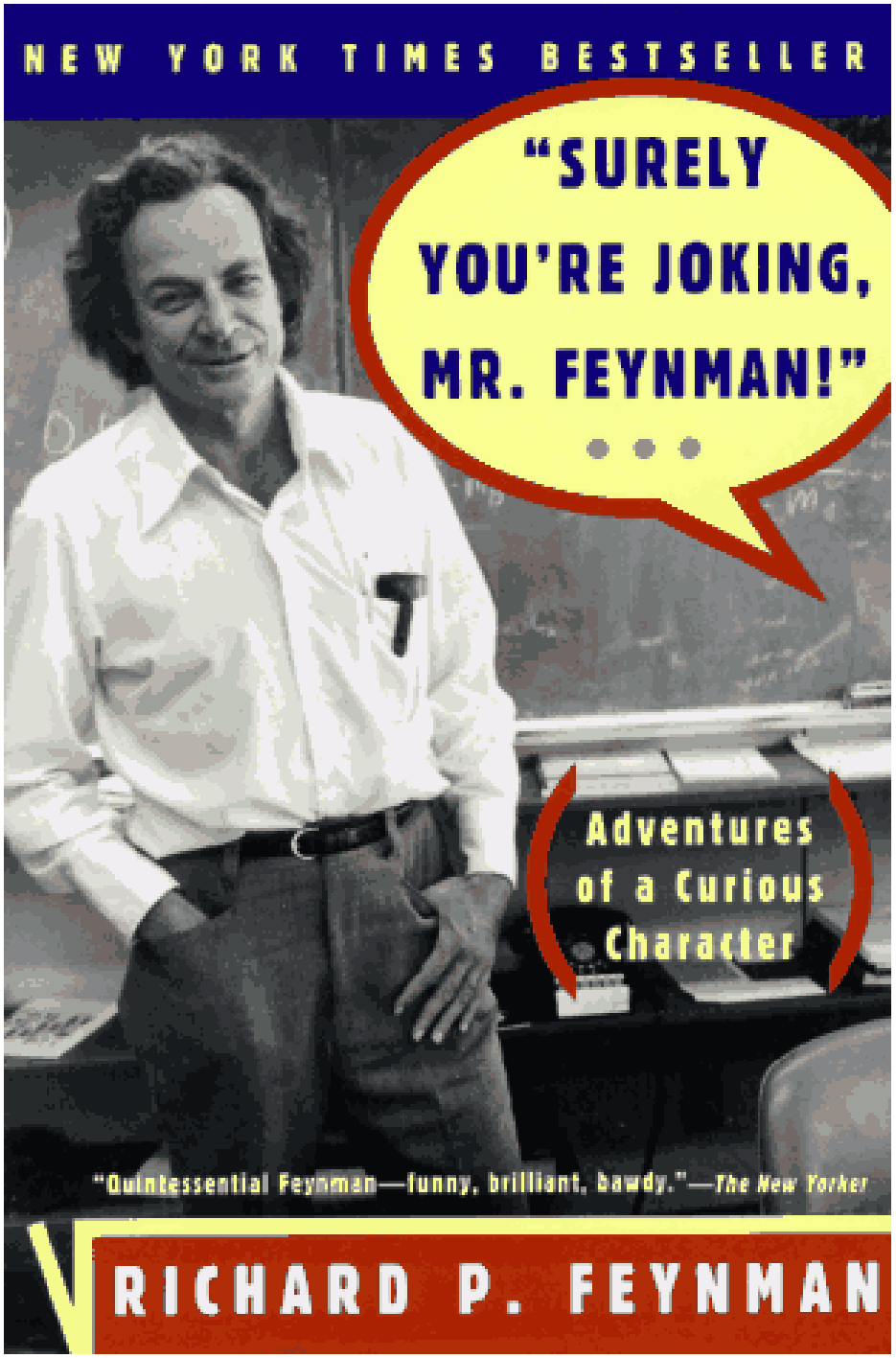
Einstein, ca. 1905

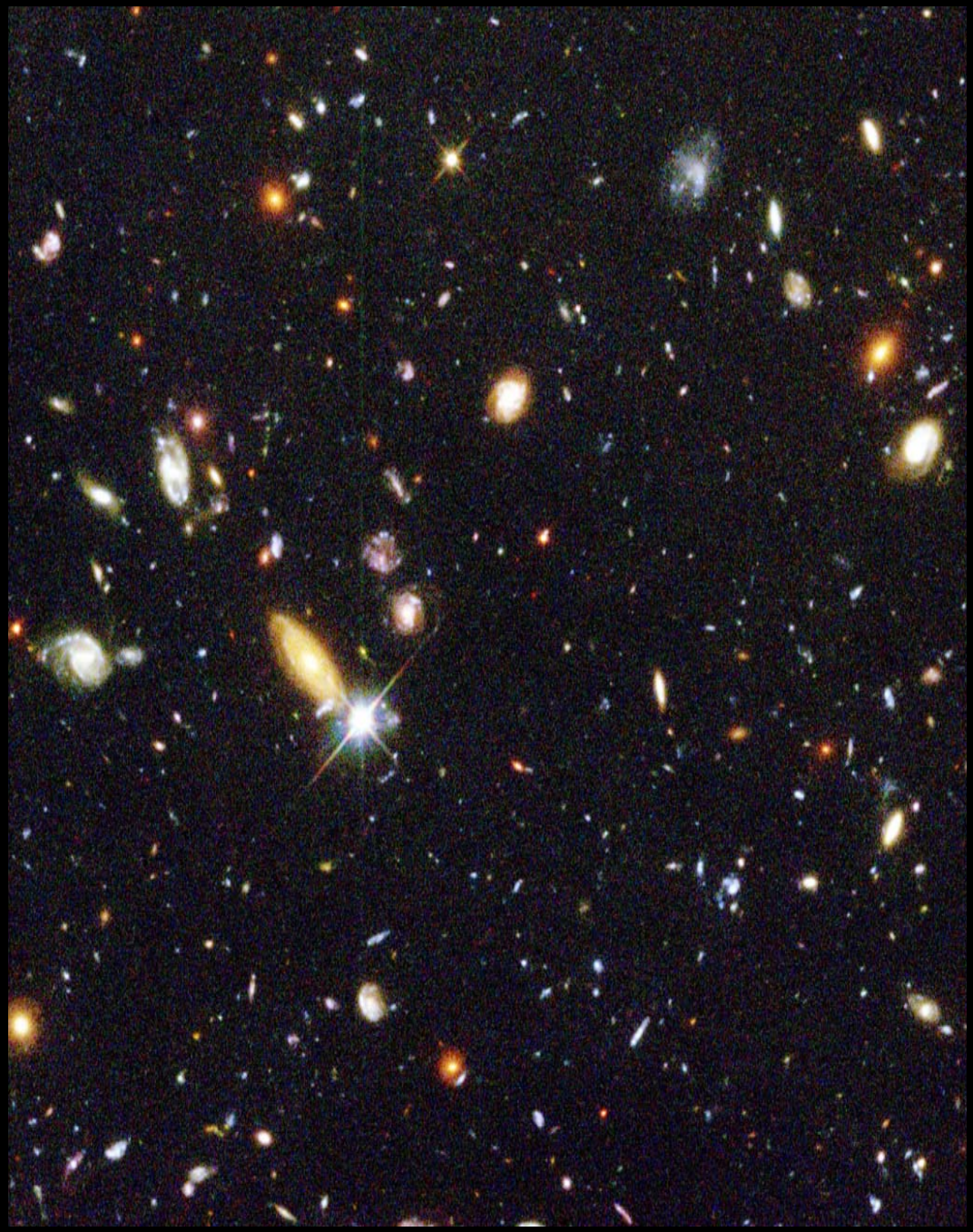
**"When the Special Theory of Relativity began to germinate in me, I was visited by all sorts of nervous conflicts... I used to go away for weeks in a state of confusion."**

**"A storm broke loose in my mind."**

Einstein, ca. 1905

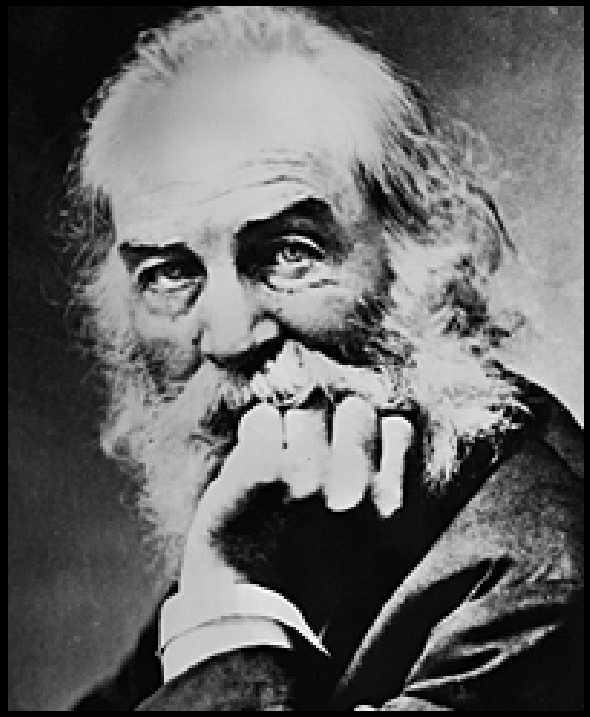

TUVA OR BUST!


NEW YORK TIMES BESTSELLER
"SURELY YOU'RE JOKING, MR. FEYNMAN!"
Adventures of a Curious Character
"Quintessential Feynman—funny, brilliant, bawdy."—The New Yorker
RICHARD P. FEYNMAN



**Every cubic inch of space is a miracle!**

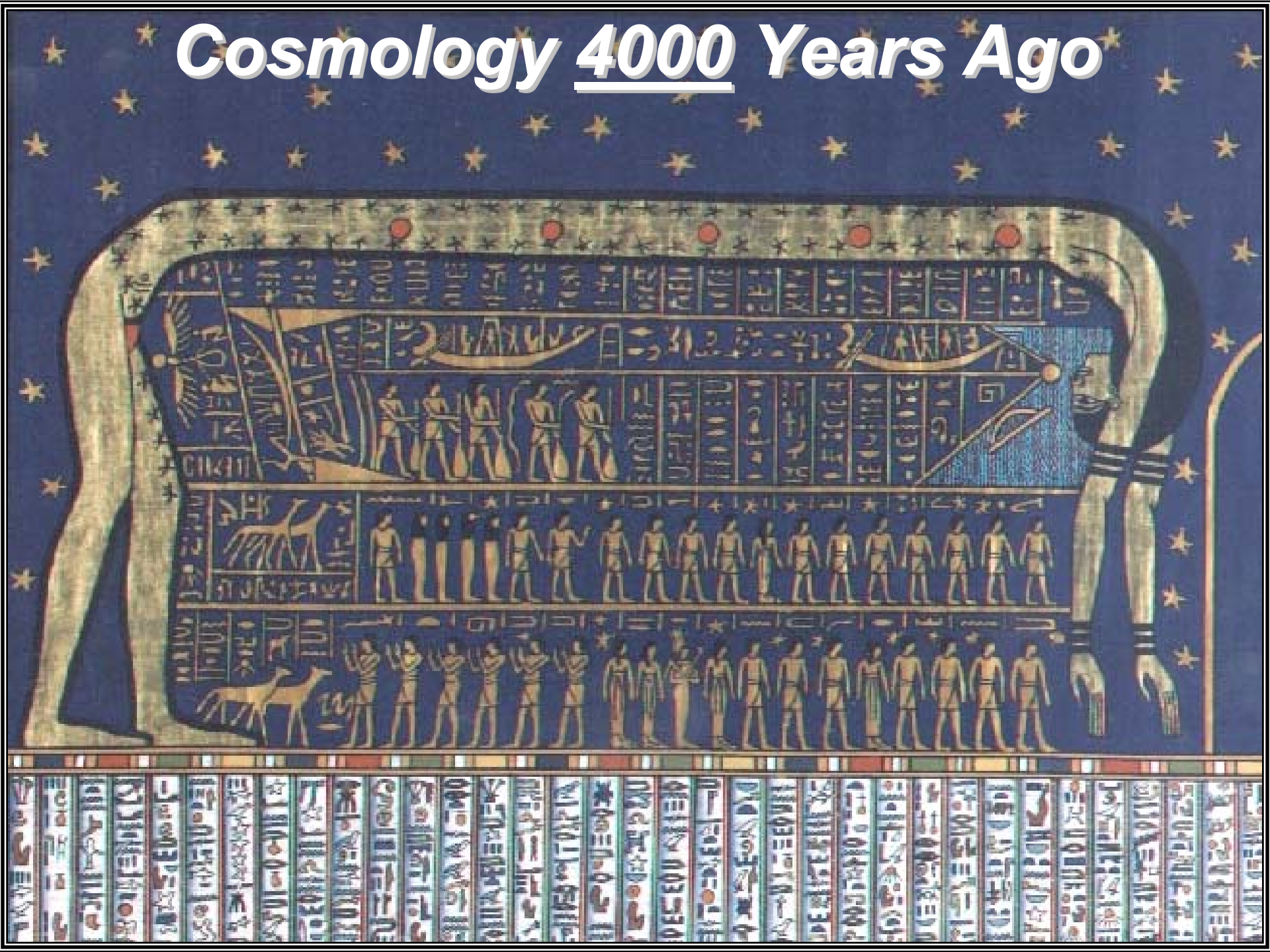
- **cosmic radiation**
- **virtual particles**
- **Higgs potential**
- **dark matter**
- **dark energy**



cosmology
cosmetology

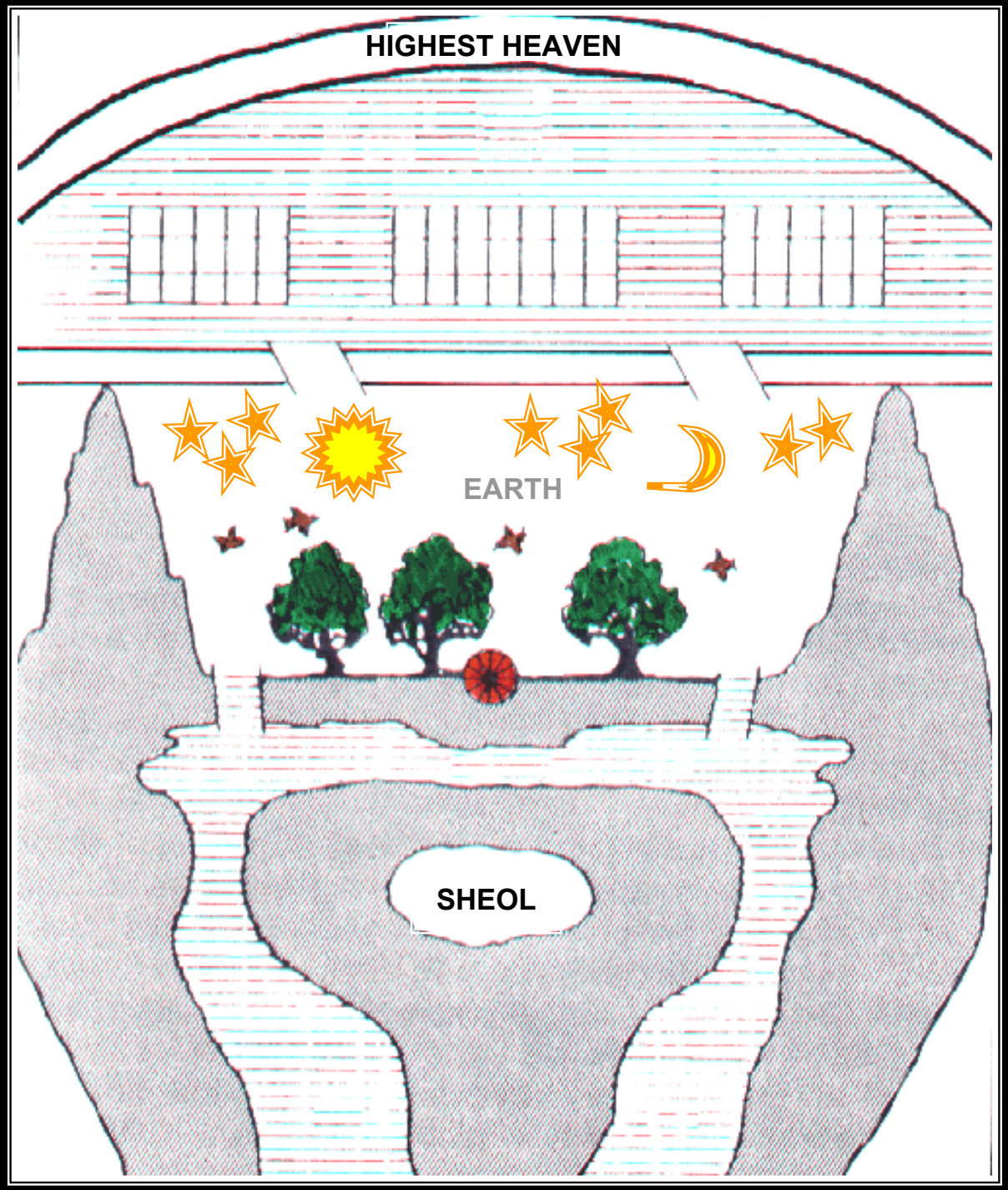
*cosmos (κόσμος)*

# Cosmology 4000 Years Ago



# Cosmology 1000 Years Ago

## (and Present-Day Kansas)


HIGHEST HEAVEN
EARTH
SHEOL

# The Ptolemaic Universe

Aristotle (ca. 350 BCE) – groundwork of "natural philosophy" basis for geocentric model (earth stationary).

Aristarchus (ca. 270 BCE) – proposed heliocentric model and stressed that motions are circular (Earth moves).

Hipparchus (ca. 130 BCE) – Influenced Ptolemy. Many reasonable arguments against motion of Earth. Introduced epicycles for motion of Moon.

Ptolemy (ca. 130 CE) – Greek astronomer lived in Alexandria. Astronomer, mathematician, cartographer. Books include *Almegest* & *Planetary Hypothesis.* (Κλαυδιοσ Πτολεμαιοζ)

**Claudius Ptolemaeus**
**(Ptolemy)**
Κλαύδιος Πτολεμαῖος

Μαθηματικὴ Σύνταξις
(Mathematical Compilation)

⇩

The Greatest Compilation

⇩

al-majisti

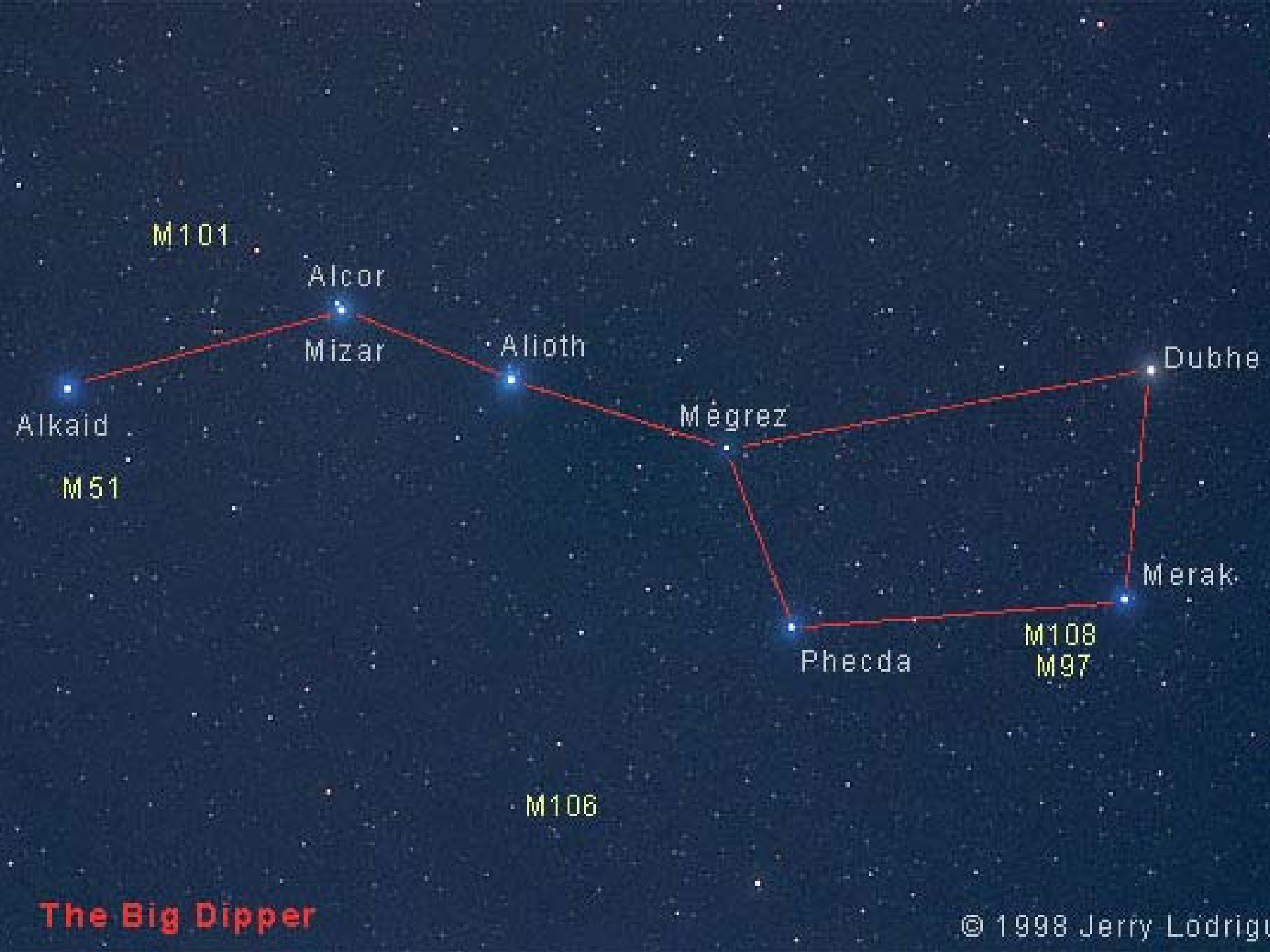
⇩

The Almagest

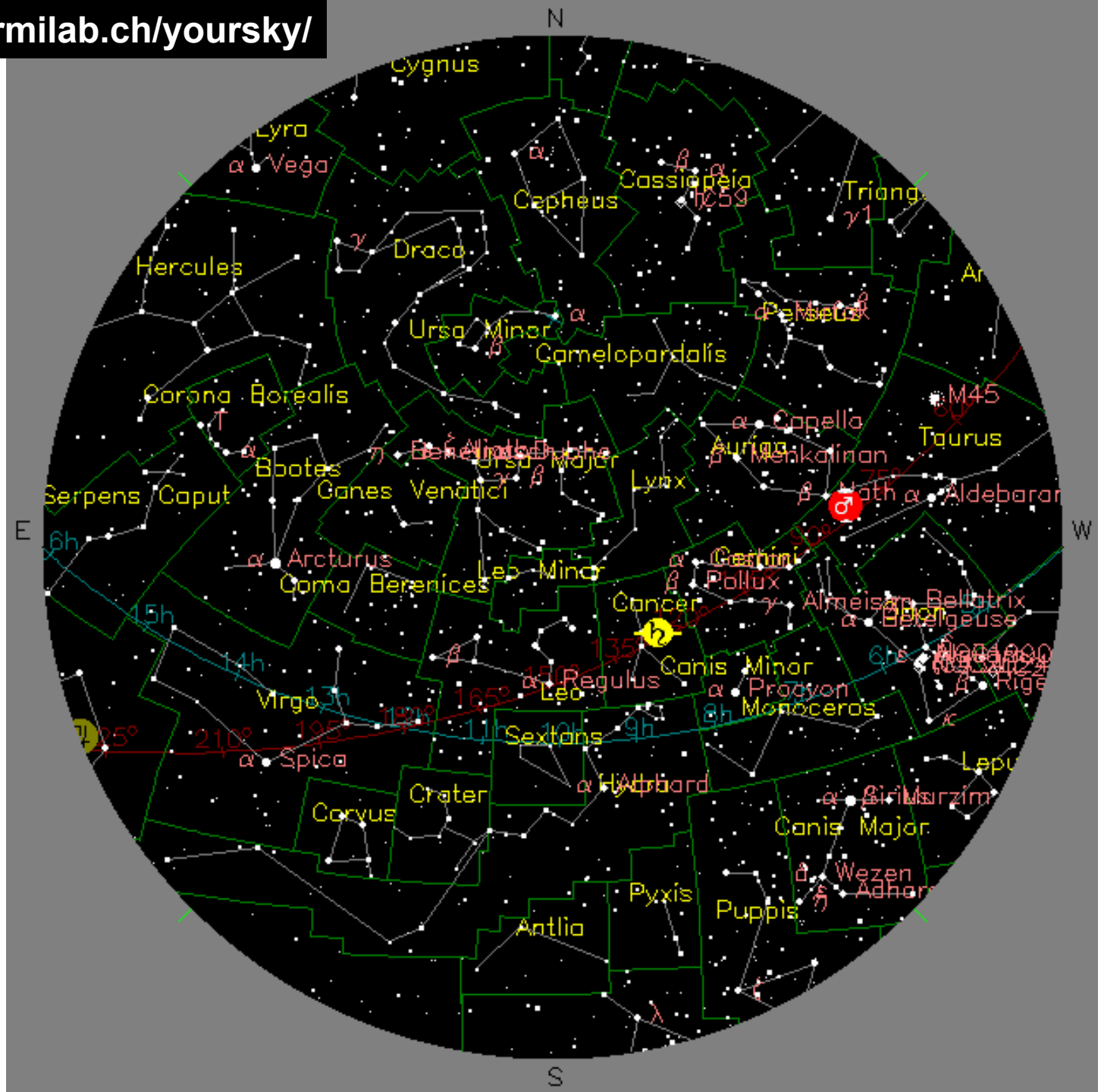
| | |
|---|---|
| Sun | moves |
| Moon | moves & phases |
| Planets | move |
| Stars | move |
| Eclipses | |
| Clouds | |
| Birds | |
| Rainbows | |
| Comets, meteors, etc | |

Motion of planets different than motion of stars

Planet = wanderer


M101
Alcor
Mizar
Alioth
Dubhe
Alkaid
Megrez
M51
Merak
Phecda
M108
M97
M106
The Big Dipper
© 1998 Jerry Lodrigu

www.fourmilab.ch/yoursky/

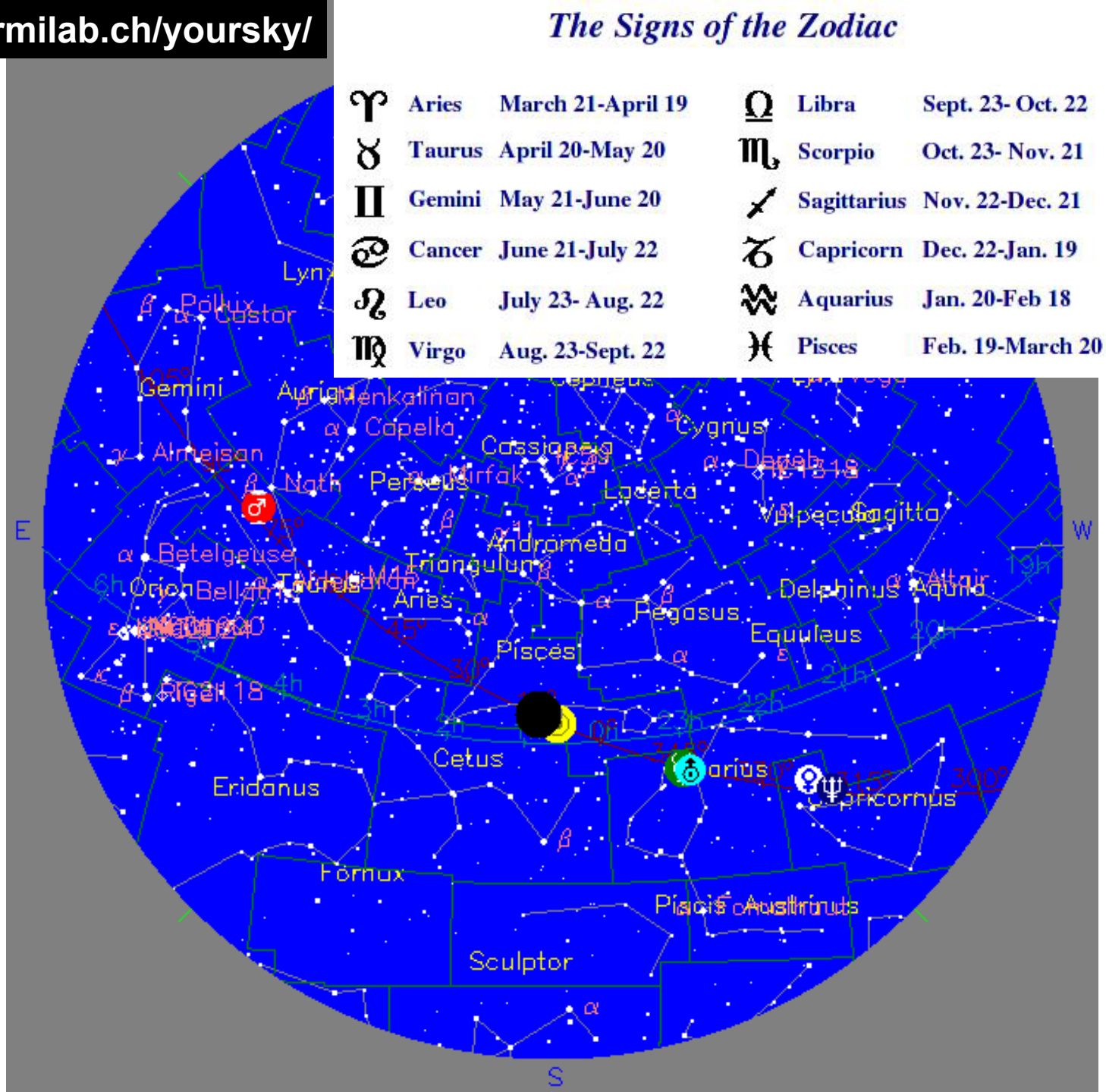



29 March, 2006 03:30 UTC

41°52′27″N 87°38′21″W

North
East
West
South

www.fourmilab.ch/yoursky/



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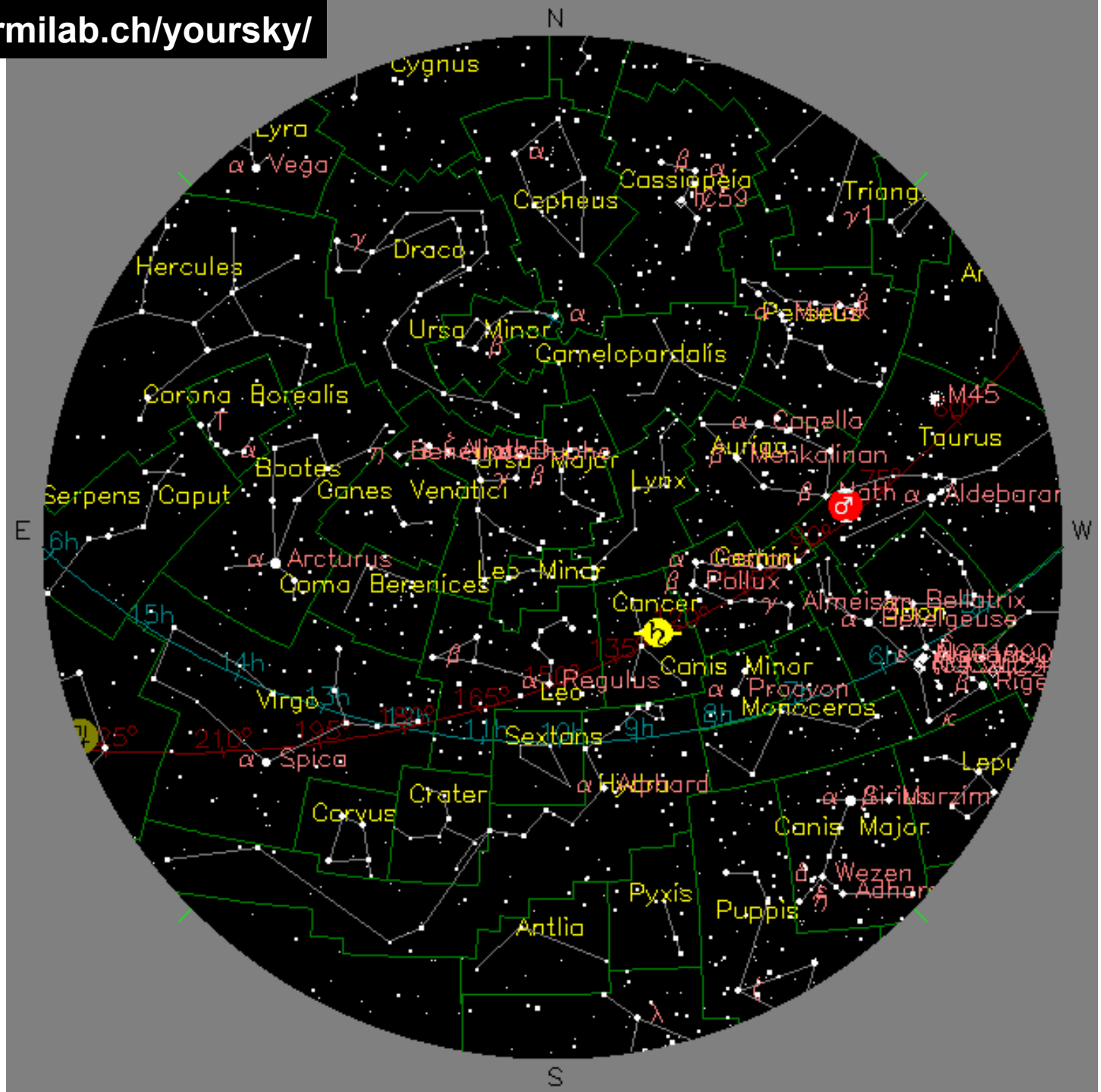


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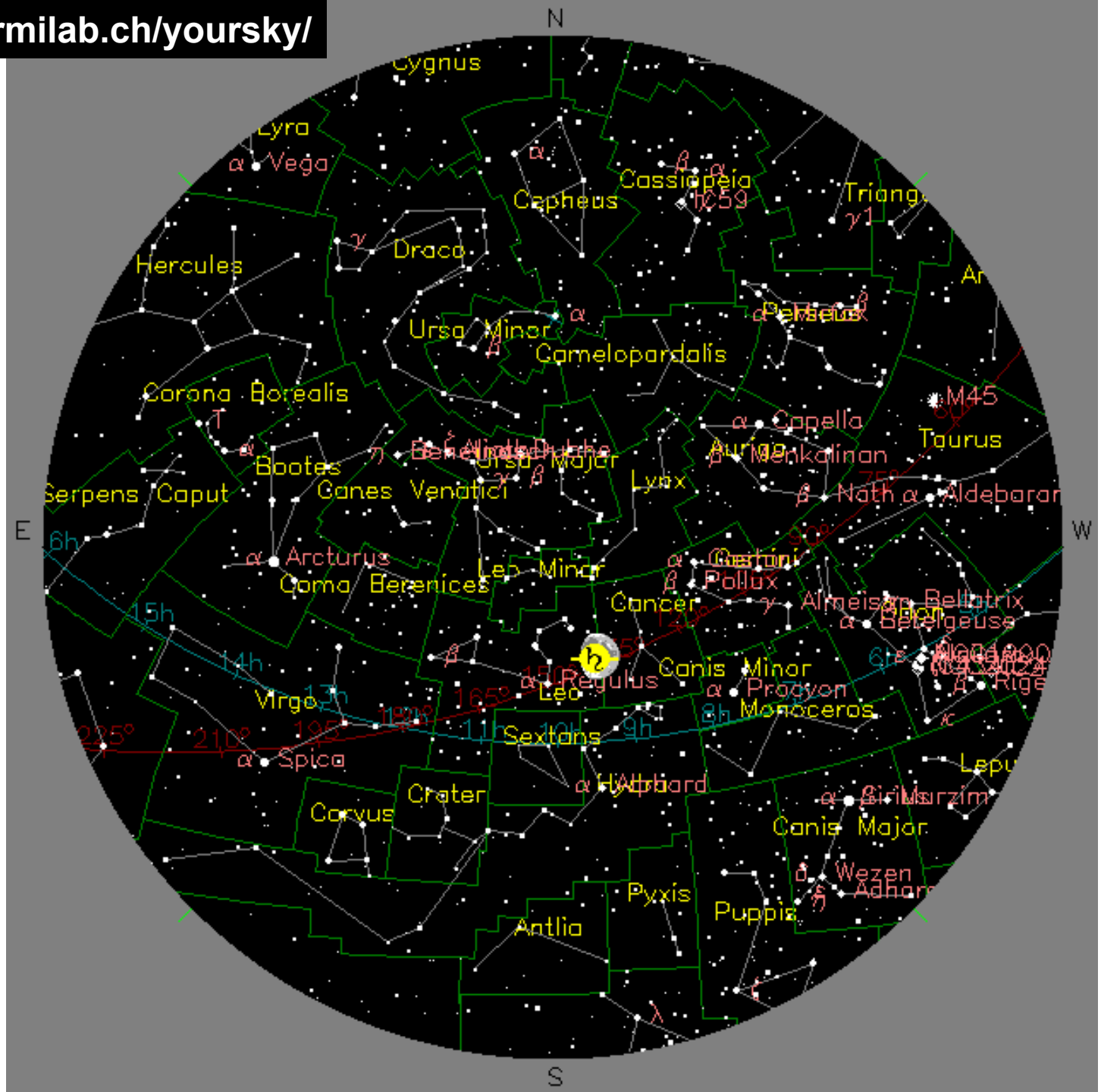
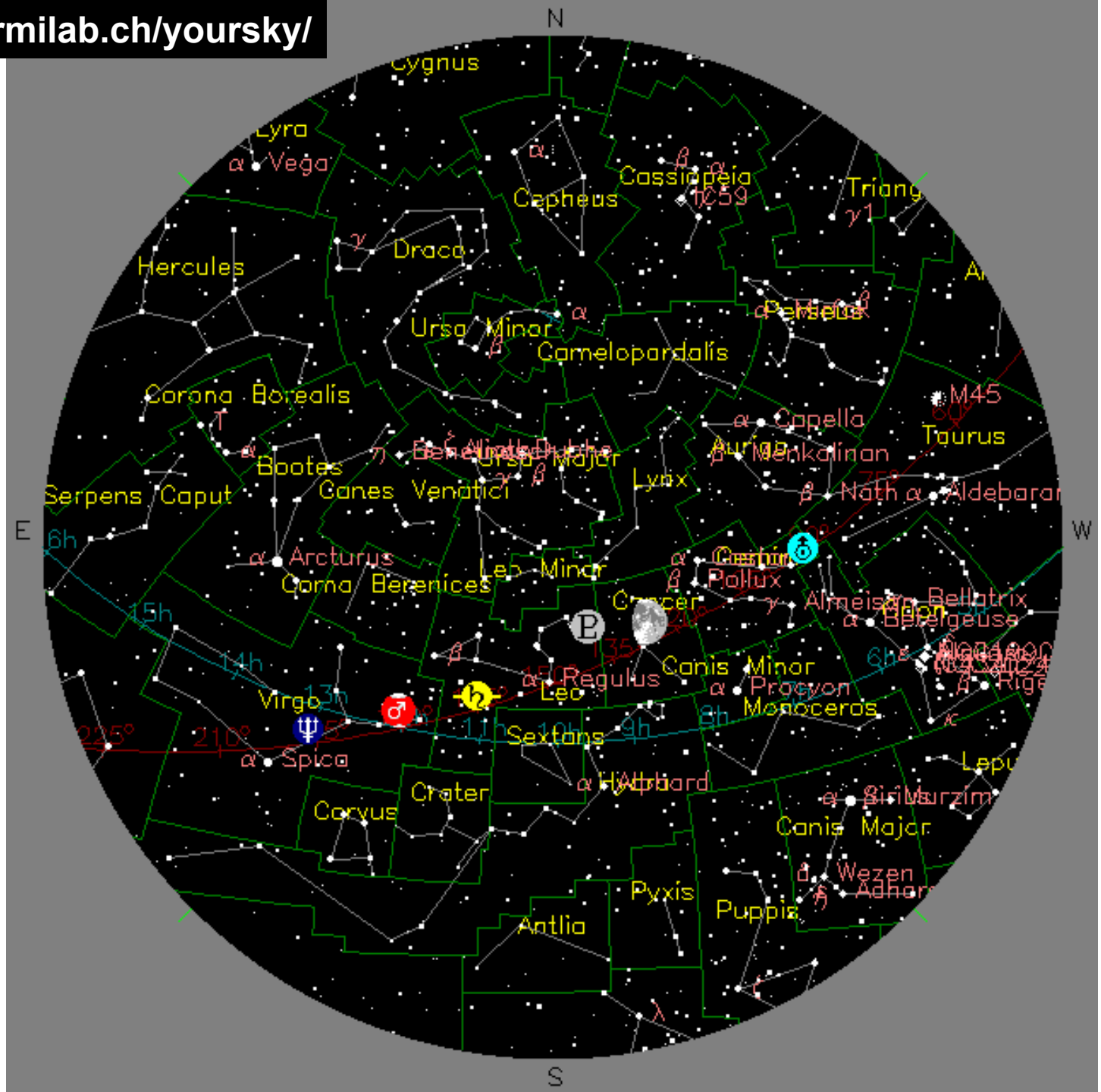



- Sun
- Mercury
- Venus
- Earth
- Mars
- Jupiter
- Saturn
- Uranus
- Neptune

29 March, 2007 03:30 UTC

41°52′27″N 87°38′21″W

www.fourmilab.ch/yoursky/

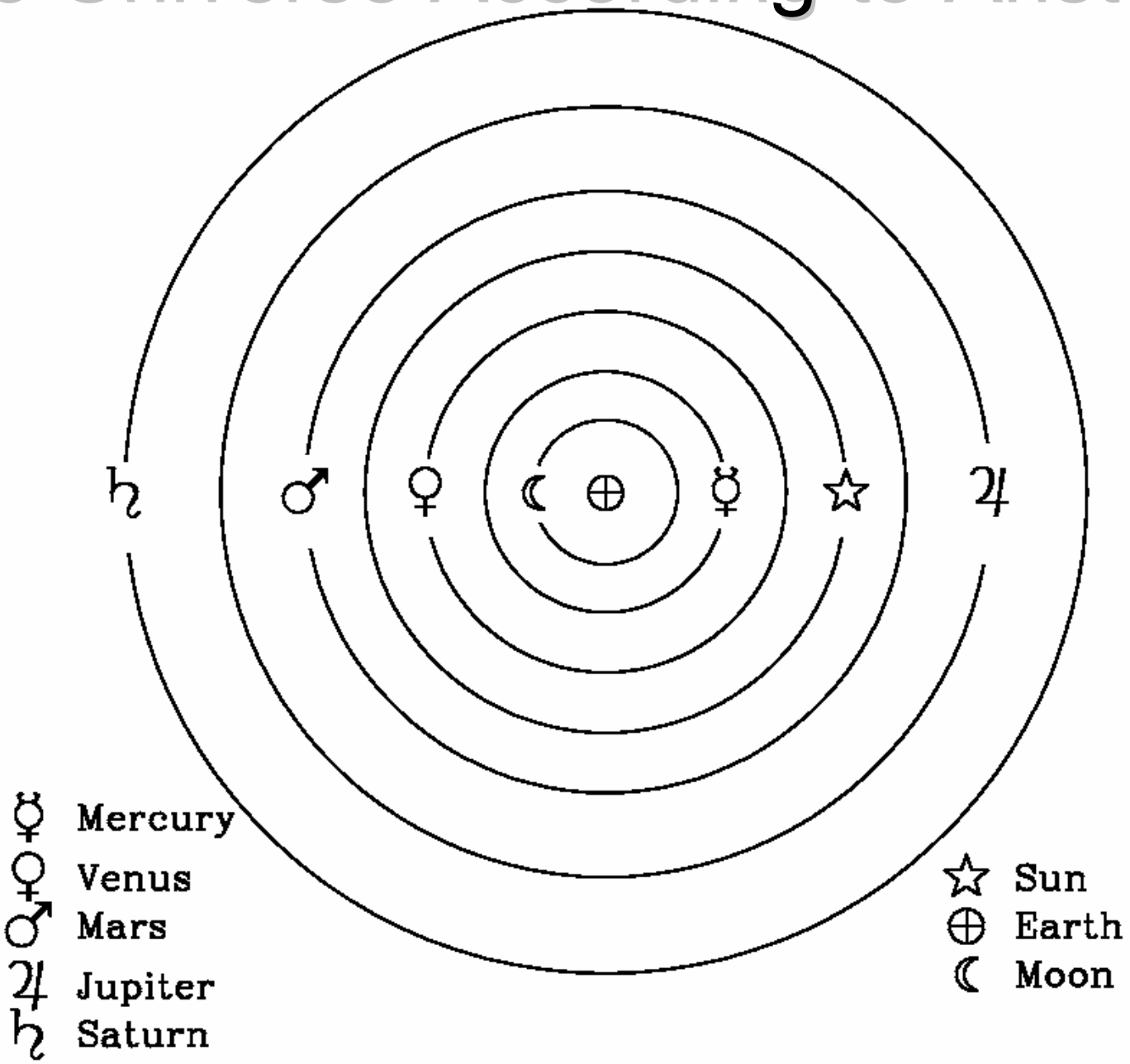



- Sun
- Mercury
- Venus
- Earth
- Mars
- Jupiter
- Saturn
- Uranus
- Neptune

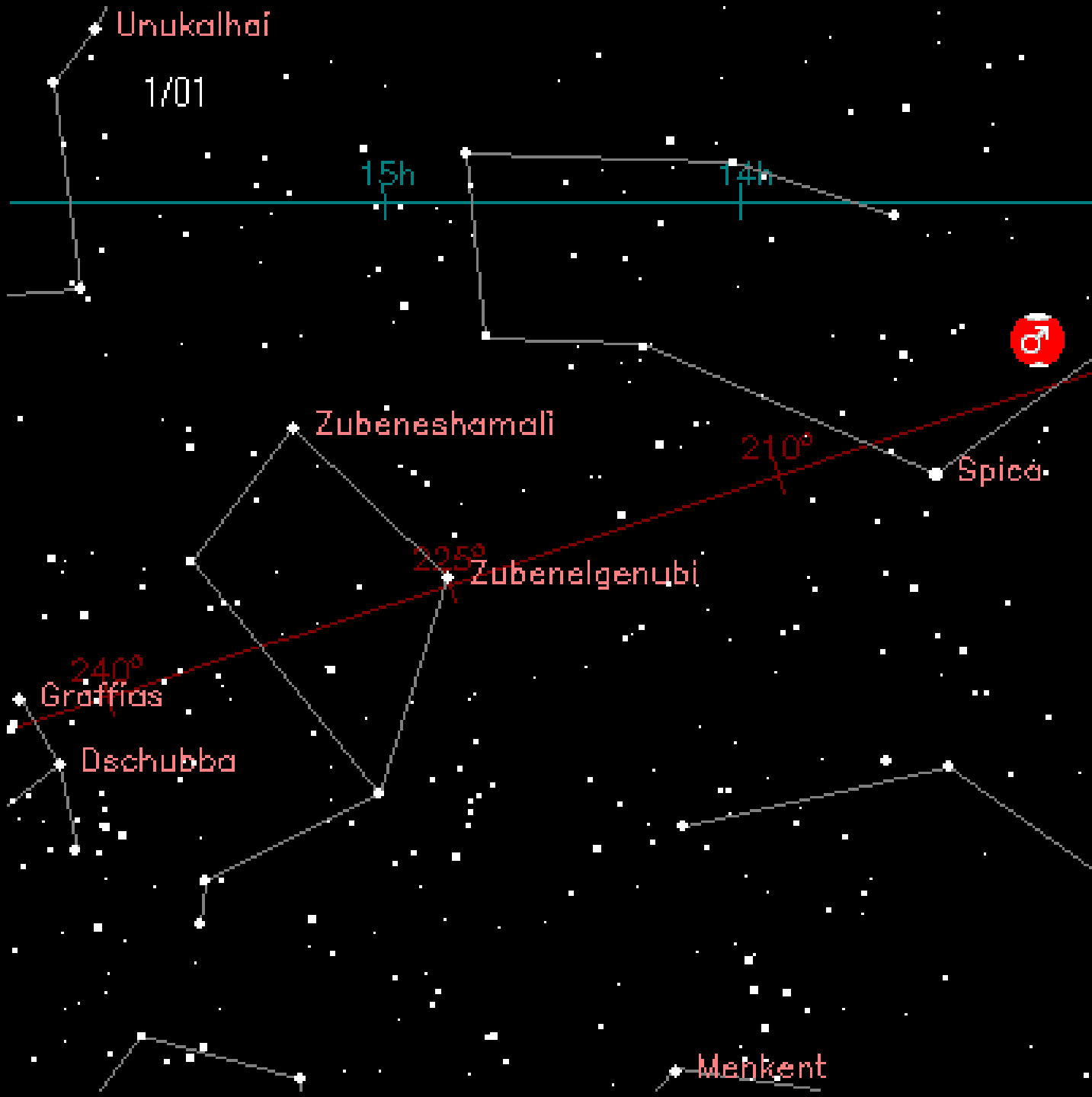
29 March, 1950 03:30 UTC

41°52′27″N 87°38′21″W

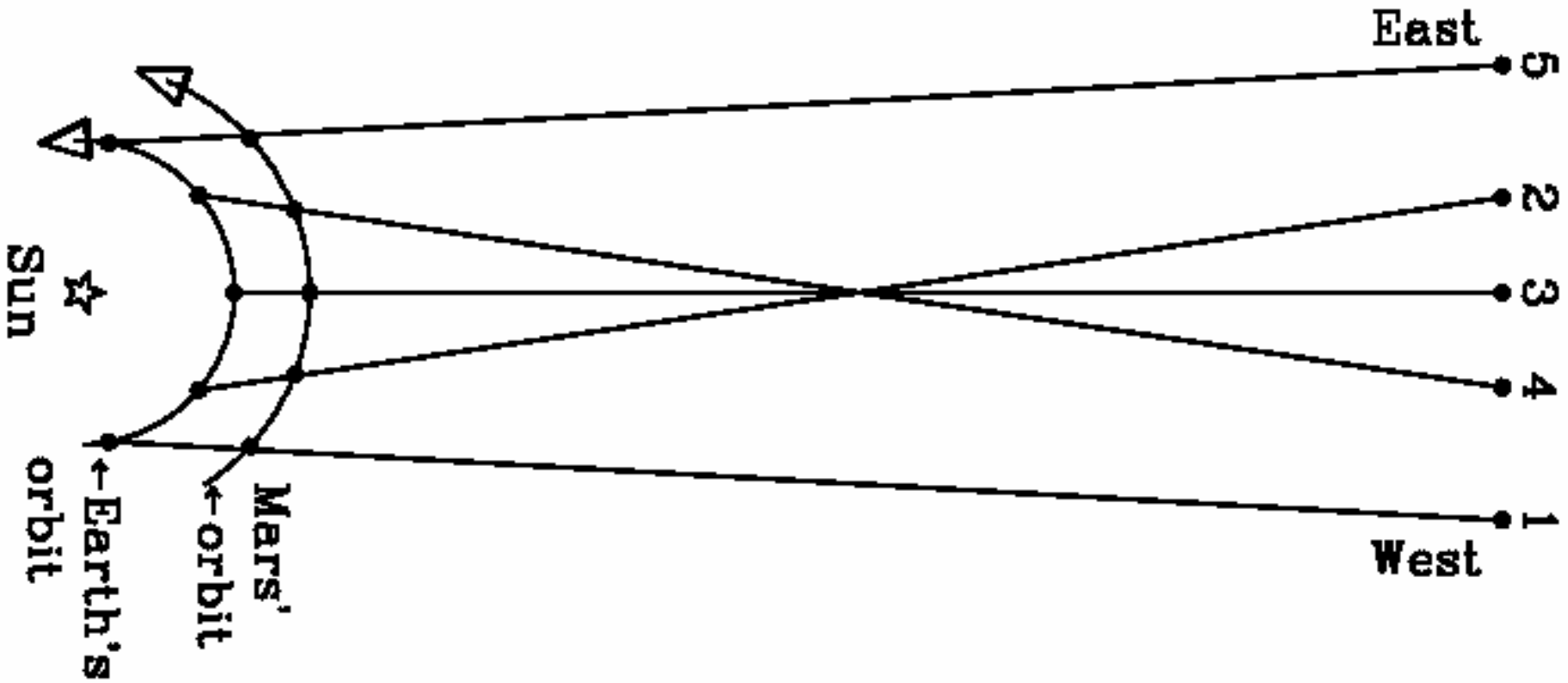
# The Universe According to Aristotle



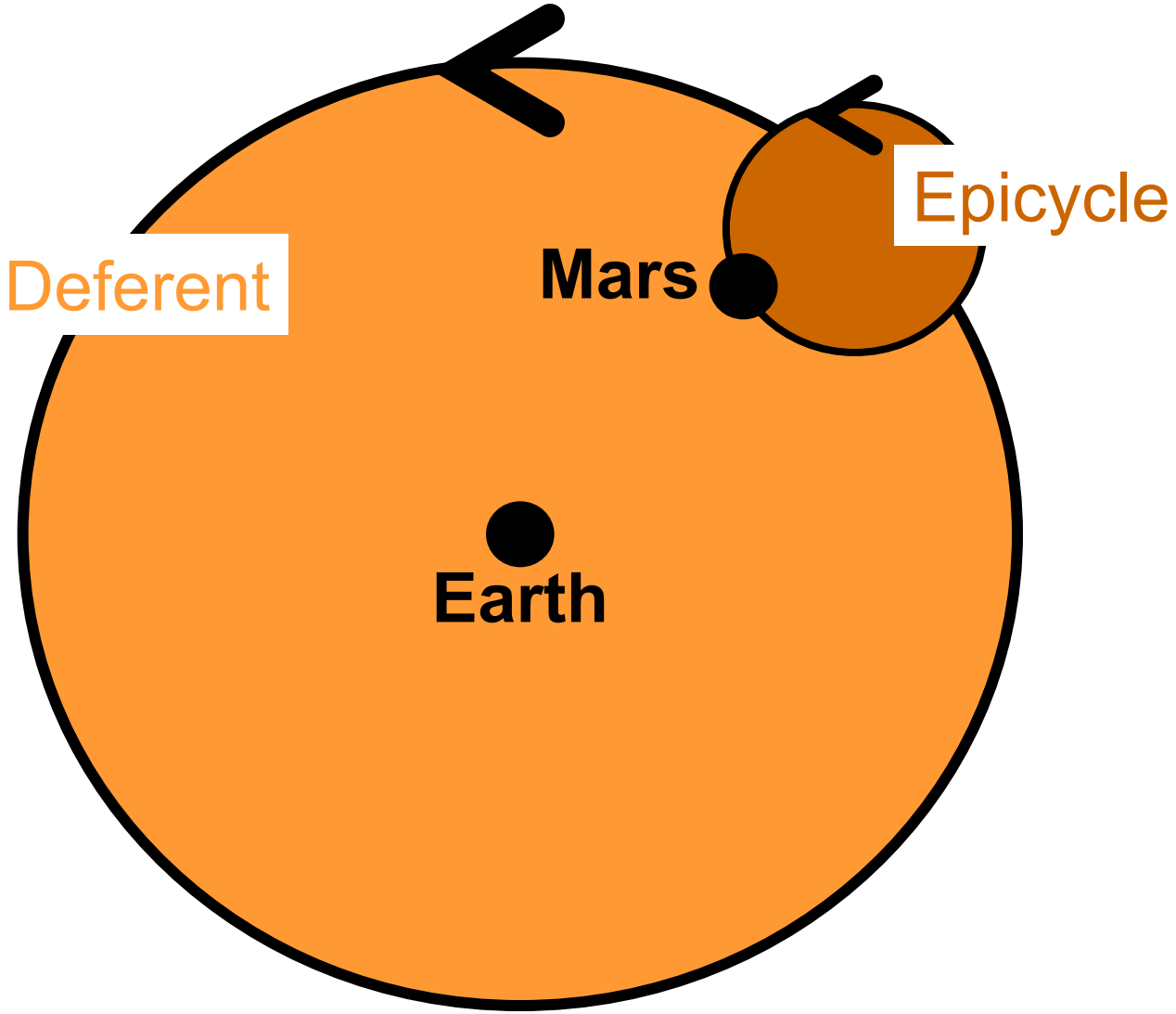
**Retrograde motion of Mars between 01/01/99 and 08/29/99**



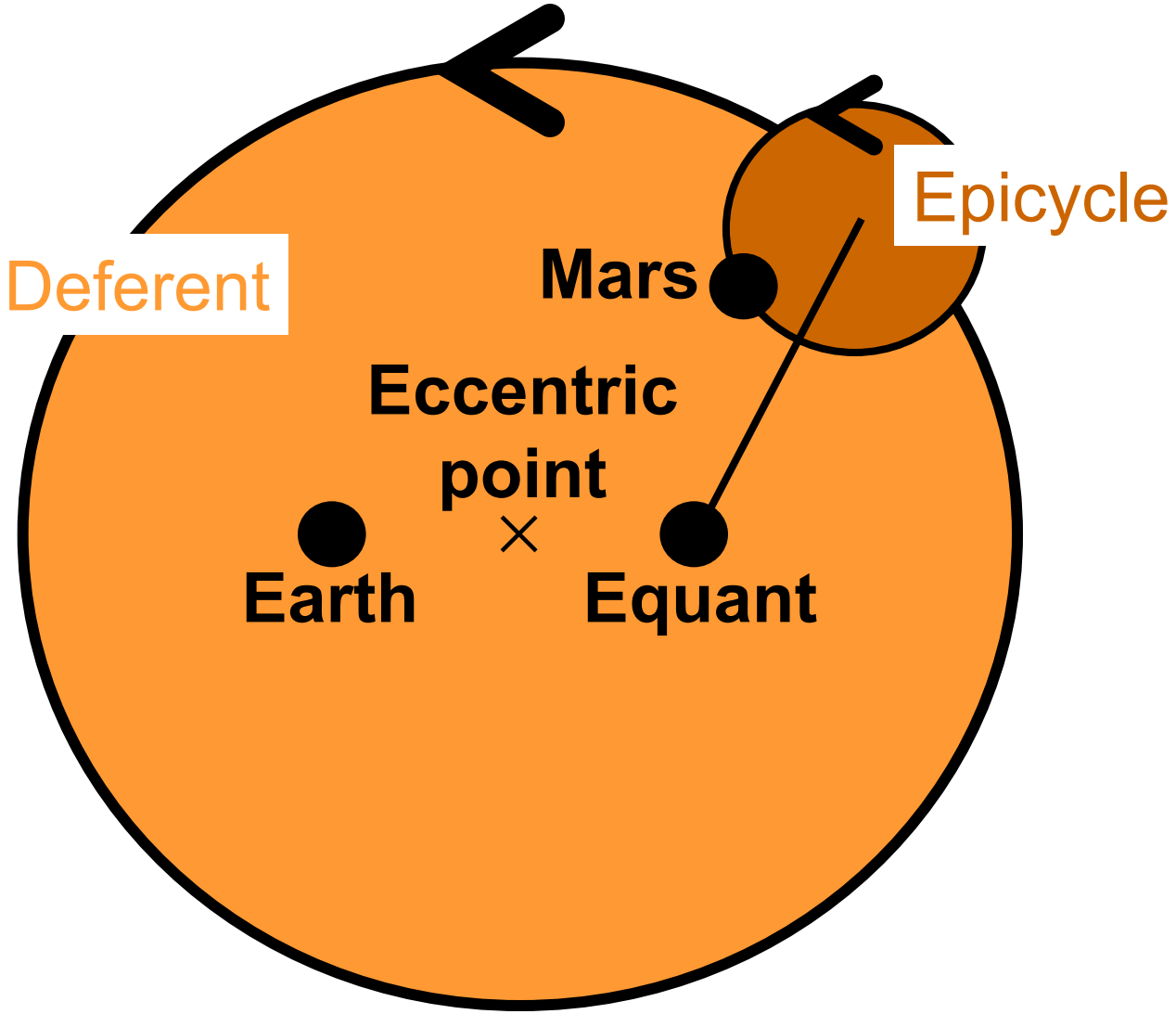
# Retrograde Motion



# The Ptolemaic Epicycle



# The Ptolemaic Epicycle

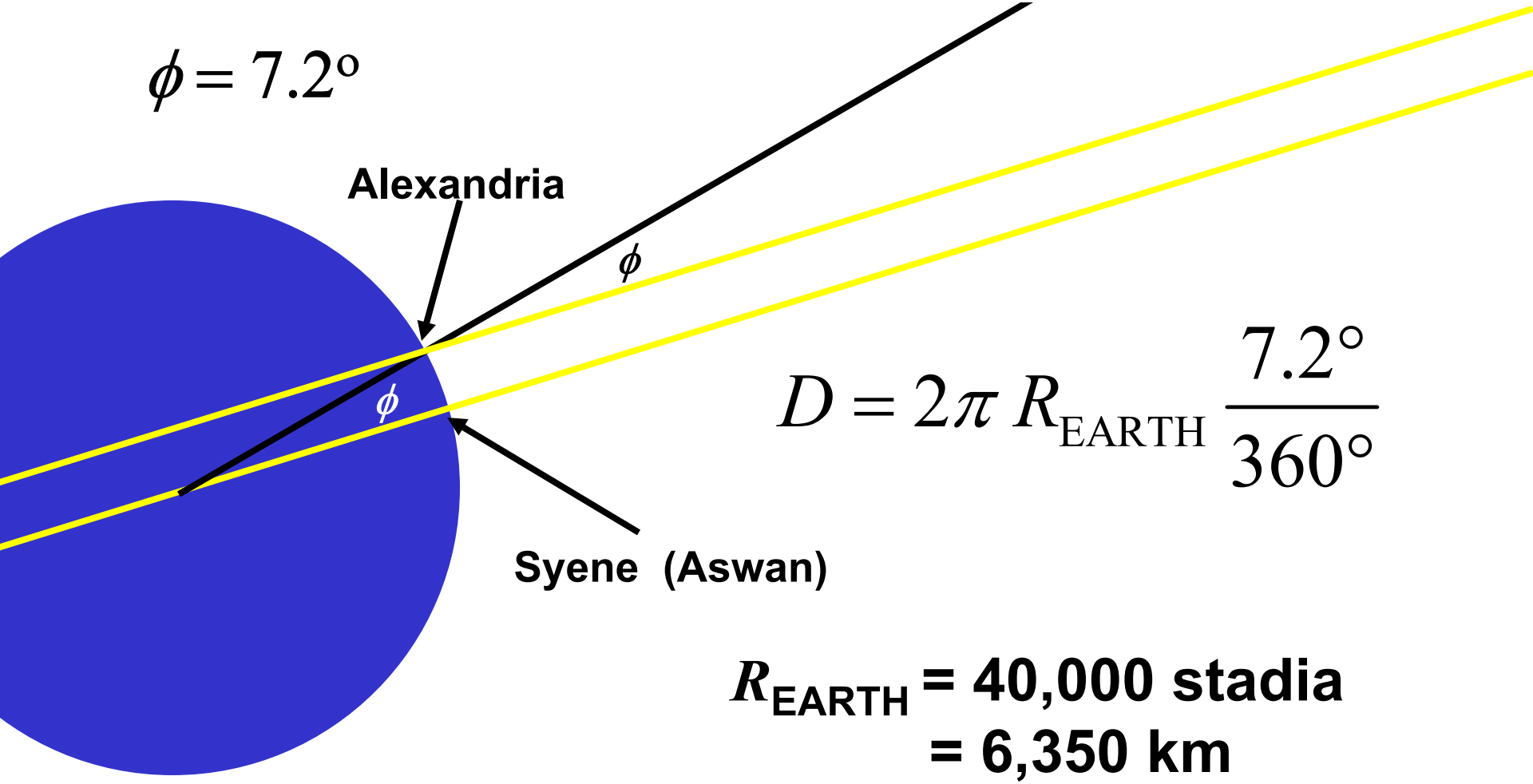


# Size does matter

# Size of Earth (Erathosthenes ~ 250 BC)

**$D$ = distance between Syene & Alexandria = 5000 stadia**

$$\phi = 7.2^{\circ}$$

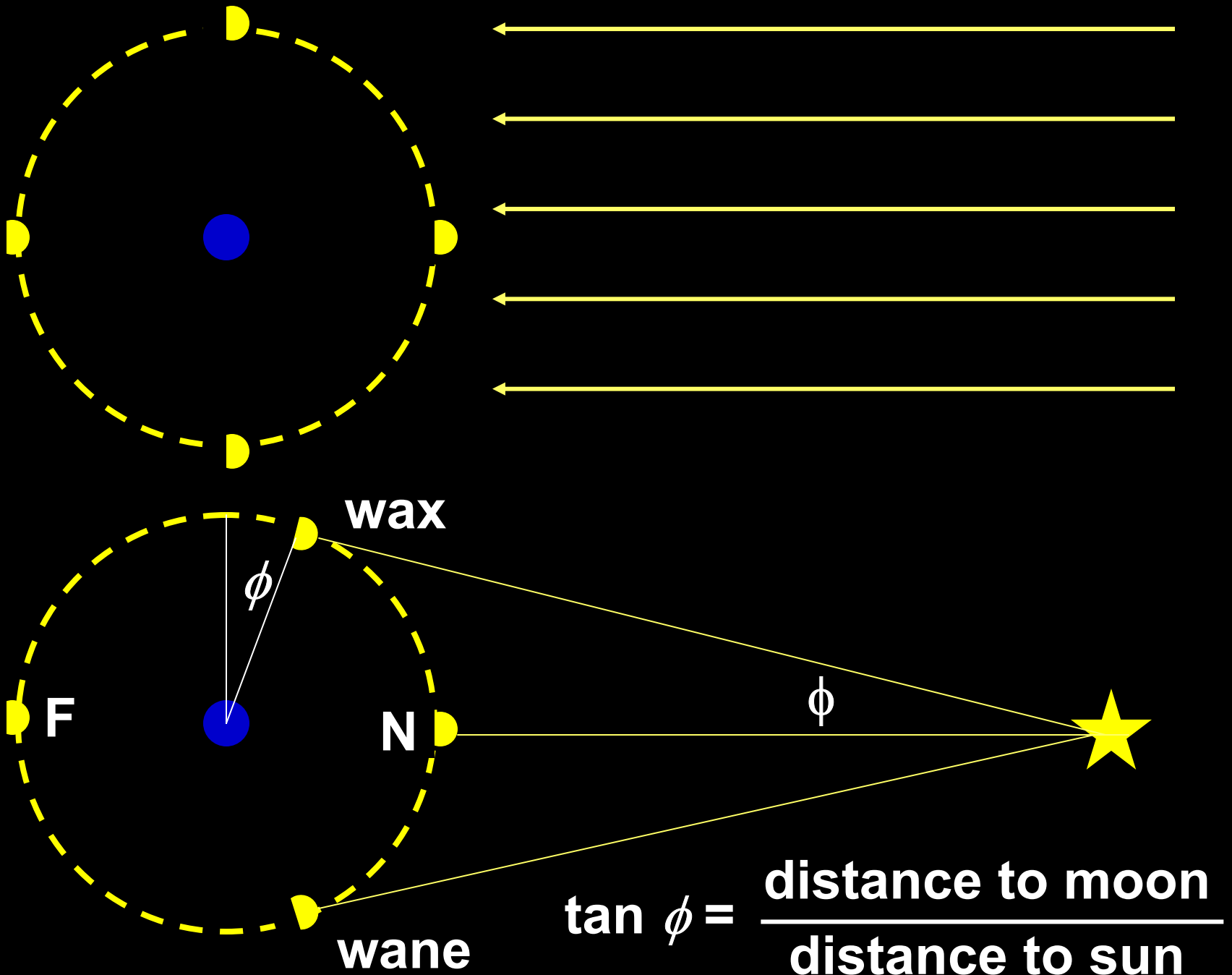



$$D = 2\pi R_{\text{EARTH}} \frac{7.2^{\circ}}{360^{\circ}}$$

**$R_{\text{EARTH}}$ = 40,000 stadia**
**= 6,350 km**

$$\frac{\text{distance to the sun}}{\text{distance to the moon}}$$ (Aristarchus ~ 270 BC)

sun always illuminates half the moon


SUN
wax
ϕ
F
N
ϕ
SUN
wane
tan ϕ = distance to moon / distance to sun

Aristarchus said time between new moon and waxing moon was 12 hours shorter than the time between the full moon and the waning moon.*

$$\frac{\text{distance to sun}}{\text{distance to moon}} = 19$$

390 is correct
but geometry is perfect

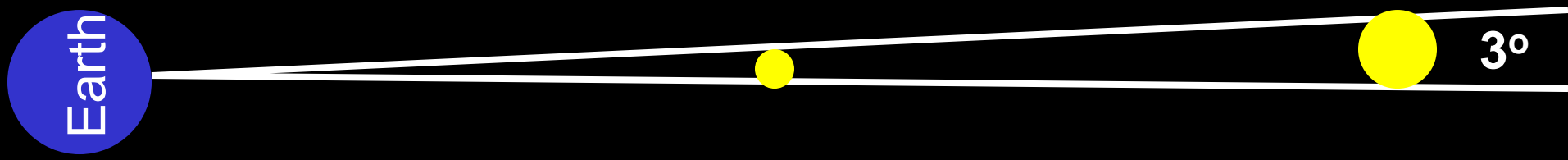
---

* Actual time difference is about ½ hour.

# The distance ladder

- The radius of Earth is known
- Distance to the moon in terms of Earth's radius
- Distance to the sun in terms of the distance to the moon, which in turn is known in terms of the radius of Earth
- Leads to a knowledge of the "size" of the object

- How big are things?
- How far away are things?




**Both objects have an angular size of 3°**

| Object | Distance from Earth (in miles) | | Radius (in miles) | | Angular Size (in degrees) | |
|---|---|---|---|---|---|---|
| | Ptolemy | True | Ptolemy | True | Ptolemy | True |
| Earth | ——— | ——— | 3,750 | 3,960 | ——— | ——— |
| Moon | 225,000 | 239,000 | 940 | 1,080 | 1/2 | 1/2 |
| Sun | 4,700,000 | 92,900,000 | 21,000 | 432,000 | 1/2 | 1/2 |